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THE PROGRAM FOR INDIVIDUALLY PRESCRIBED INSTRUCTION.

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PROGRESS DURING THE FIRST YEAR OF THE OAKLEAF PROJECT, AN INDIVIDUALIZED INSTRUCTIONAL PROGRAM FOR ELEMENTARY SCHOOL STUDENTS, WAS SUMMARIZED IN THIS INTERIM REPORT. THE OAKLAND ELEMENTARY SCHOOL IN SUBURBAN PITTSBURGH WAS USED AS THE PROJECT LABORATORY FOR PRODUCING A CURRICULUM IN AN EDUCATIONAL ENVIRONMENT WHICH WOULD BE RESPONSIVE TO INDIVIDUAL DIFFERENCES AMONG CHILDREN. SUBJECT-MATTER LEARNING WAS CONCENTRATED ON MATHEMATICS, READING, AND PRIMARY-GRADE SCIENCE. SELF-STUDY MATERIALS AND DIAGNOSTIC TESTS WERE DEVELOPED AND BUILT INTO THE INDIVIDUALIZED CURRICULUM. TEACHERS WERE RESPONSIBLE FOR WRITING PRESCRIPTIONS OF LEARNING EXPERIENCES REQUIRED FOR FULFILLING EACH STUDENT'S INDIVIDUAL NEEDS. TABLES IN THE CONCLUDING SECTION OF THE REPORT PROVIDE INDIVIDUAL STUDENT PROGRESS DATA DURING THE PROJECT'S FIRST YEAR. RELATED REPORTS ARE ED 010 205 THROUGH ED 010 211 AND ED 010 519 THROUGH ED 010 523. (JH)

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THE PROGRAM FOR INDIVIDUALLY PRESCRIBED INSTRUCTION

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THE PROGRAM FOR INDIVIDUALLY PRESCRIBED INSTRUCTION

Robert Glaser

There are two principle problems in researching and developing systems for implementing individualized instruction: One is the psychological study of the interaction between individual difference variables and learning treatments, and the second is experimentation in school systems with strategies and materials for adapting to individual differences.

A good way to get on with the first problem is to do controlled experiments which update student histories of response to subject matter as a basis for assigning future instructional treatments. This paper and the following papers in this session discuss work on the second problem and describe research and development on the system of individually prescribed instruction being attempted in the Oakleaf School in suburban Pittsburgh. This paper is sort of an introductory description. The project on individually prescribed instruction is a study of the feasibility of procedures for producing a school environment which is highly responsive to differences among children. The description that follows represents a first cut at these matters which, at present, is only an approximation of a full-fledged system with all the nuances required for the child in the elementary school. Individualized instruction at the Oakleaf School concentrates on subject-matter learning in mathematics, reading, and primary-grade science.

To start, it is useful to examine procedures for individualization that have been or are being used. Adapting to individual differences in education can be analyzed in terms of the following patterns to borrow from Cronbach:

Pattern one assumes fixed educational goals in a fixed educational treatment. Individual differences are taken into account chiefly by dropping students along the way. Tests are used to decide which students should go faster and be imbued with higher-educational aspirations. A weeding-out process, reached earlier or later by various individuals, is assumed.

A variant of this pattern, is to permit an individual to stay in school until he masters, or at least learns to a specified criterion, certain essential and common educational outcomes. This pattern is practiced in the old policy of keeping the child in the first grade until he can read his primer, and in the more recent non-graded primary unit which some children complete in two years and some in four.

A second pattern of adaptation to individual differences is to determine for each student his prospective future role and provide for him an appropriate curriculum; goals are matched to the individual. We see this system in operation when students are channeled into academic courses, vocational courses, or homemaking courses -- or in the decision to give the vocationally oriented students one kind of mathematics and the academically oriented another kind. This second pattern assumes that an educational system has provision for optional educational objectives, but within each option the instructional treatment is relatively fixed.

A third pattern of adaptation to individual differences attempts to teach different students by different instructional procedures; within each of these instructional treatments there is a minimum fixed sequence of educational goals which must be mastered. This pattern of adaptation can be implemented in a variety of ways: at one extreme a school can provide a fixed instructional sequence, and students are pulled off the track for remedial work; then, when the damage is repaired he is put back into the general track. At the other extreme, an instructional program can provide detailed diagnosis of the student's competencies on the basis of which a unique prescription is made for a course of instruction tailored to that student. In this latter procedure some students might learn on their own by discovery, some learn by more structured methods, some learn by reading, some by listening, etc.

Between these two extremes, toward the direction of the latter, lies the kind of adaptation to individual differences that the Individually Prescribed Instruction plan at Oakleaf hopes to attain. The quality of the system developed depends upon the answer to many research and practical implementation questions. How well can individual student needs be diagnosed? How well can we write instructional prescriptions based on student information?; what is the character of the information required? Research seems to indicate that in the presence of inadequate information, it may be best for teachers to follow an average treatment for everybody and not attempt to differentiate on the basis of unreliable information; but with reliable information and techniques for making instructional decisions, effective student differentiation is possible.

However, proof will have to be forthcoming that the assignment of instructional methods does indeed interact with student differences so that their achievement in seeking a given educational goal is significantly greater than if an average best method were employed. The Oakleaf project represents a step taken in an on-going school to investigate this.

In its present stage of development the Individually Prescribed Instruction procedure adapts to individual differences in the following ways:

(1) It starts each pupil from where he is on the learning continuum and takes him from there. It establishes this entering level through a series of detailed placement examinations which establishes the student's attainment in a subject matter and identifies his strengths and weaknesses. A student starts his instruction from this point.

(2) The instruction the student receives is differentiated according to his performance as he learns. Curriculum-embedded and subgoal tests tell whether the student has mastered the subject matter at a required level. On the basis of this performance, new materials, to a large extent self-study materials, are prescribed for him.

(3) Students are differentiated in terms of three kinds of instructional treatments resulting from (a) their ability to transfer to new knowledge, (b) their need for additional practice, and (c) their opportunity for extended experience. Transfer as used here refers to the fact that a student may learn an advanced lesson in the process of learning a more basic one and can use his knowledge in carrying out more complex performance. As a result, he can skip a portion of the curriculum if it

is shown that he does not need to be taught it. When a student completes a unit at Oakleaf, he takes a test not only on what he has covered but also on what he is about to cover next. On the basis of his performance on what he is about to cover, it is possible for the teacher to omit certain lessons and prescribe more advanced ones. Further differentiation takes place specifically for each student by additional practice, the requirement for more drill, and/or different approaches to instruction. Extended experience refers to the fact that at a given level of learning it is possible for a teacher to prescribe excursions which wonder off into interesting paths. At the present time in Oakleaf, the procedures for taking account of transfer and additional practice are much more formalized and built into our test development than our procedures for insuring extended experience.

(4) Quality control of student learning and attainment is accomplished by introducing the concept of mastery levels throughout the curriculum. Performance standards which are used as the basis for making decisions concerning the pupil's future course of instruction are specified. We set mastery standards based upon the judgment of our curriculum writers and teachers and use these standards as decision criteria for assigning the next instructional steps. The determination of specific mastery levels for various subject matter is an experimental problem which needs to be studied. How much mastery should be required, for example, in learning basic arithmetic facts before moving on to an advanced topic? Is more rapid learning and better retention achieved if a student is permitted to go on in a subject matter where advanced lessons

depend on previous lessons or is it best to require an early high level of mastery? We are obtaining some interesting data here.

At the present time, the extent to which the Oakleaf curriculum can provide different instructional procedures for different students is a function of: (1) the kind of self-study and other materials and diagnostic tests that have been built into our curriculum for the teachers and students to use; and (2) the way in which the teachers write prescriptions for each student. The prescription-writing procedure is a very essential and tricky aspect of the process at the present time. In order to make wise prescriptions, the teacher needs as much information on the student as she can get, plus data about what this information means for the kind of instruction a student should receive. A computer could print out this information for her. On the basis of this information she could then make an instructional decision which results in a prescription. At the present time, this seems to be one of the major tasks of the Oakleaf teachers. However, neither our research nor the research of others as yet gives enough detailed analysis of the relationship between the student information we provide and the instructional procedure prescribed. This is a good area for research. It should be possible to provide student information to the teacher plus information about what materials and instructional procedures to use. This can then be used as a basis for instructional prescriptions by the teacher and eventually by the teacher with computer assistance.

A further aspect of the Oakleaf curriculum is that the materials are so selected and built that it is possible for the teacher to manage individualized instruction. It also seems probable that some of this management process can be transferred to the student so that he can practice being a self-resourceful, self-editing learner.

Now to refer you to some data, the handout you have shows the six grades of the Oakleaf School during the first year of the Individually Prescribed Instruction program. The students came from conventional graded schools to this school. On the handout, each page shows a different subject area: mathematics on the first page, then reading and science on the second and third pages. Each page shows the six grades and levels at which the students were nominally placed; each bar shows the progress of an individual student in attaining mastery of each numbered sequential subject-matter unit. The black portion of a bar shows where a student was placed in the curriculum at the beginning of the year, and the shaded portion shows progress to the end of the year.

Look at the mathematics figure on the first page as an illustration. Notice the following: (1) There is a good deal of variation in placement and, hence where the children begin to work; this variability gets larger with increasing years in school. (2) Student variability in achievement at the end of one year in the program is greater than the beginning placement variability; this seems particularly true for the early grades. (3) The individual differences in rate of progress through the program are quite large. (4) The overlap in achievement levels in different grades is obvious. And (5) If you compare achievement at the

end of the year, say for the first grade, with placement level at the beginning of the year for the next higher grade, in this case the second grade, then there is a suggestion of some success on the part of the program in teaching to higher levels of achievement. This, of course, needs to be rechecked for retention effects, same students, and so forth, and this is presently being done.

As a final point I should say that we have been operating the school for about a year and a half and are beginning to learn how to handle a system for individualized instruction. At the same time, the fact that we monitor a student's learning in detail, provides us, as some of the following papers show, with a good source of data for study.

Table 1

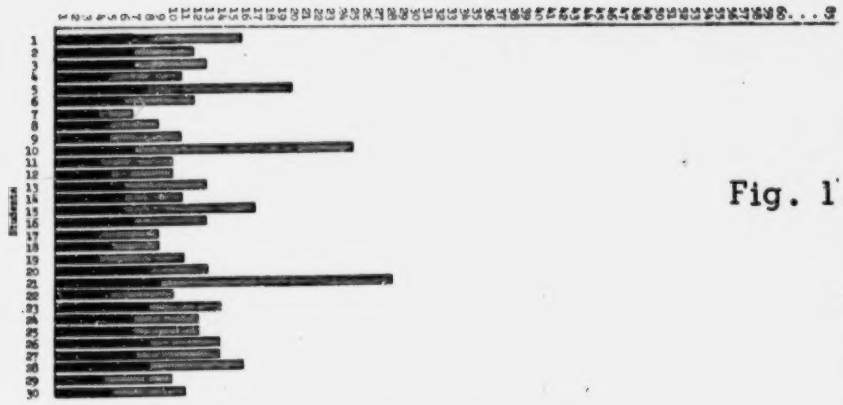
A SHORT DESCRIPTION OF MATHEMATICS UNITS

1 A Numeration - Counting to ten.
2 A Addition - Addition to sums of six with pictured objects.
3 A Fractions - Identification of 1/2 of objects and small sets.
4 A Money - Recognition of common coins (penny, nickel, dime).
5 A Time - The day as a unit of time.
6 A Systems of Measurement - Qualitative dimensional discrimination by verbal directions.
7 A Geometry - Recognition of simple geometric figures.
8 B Numeration - Counting to 100. Use of ordinals to 10th.
9 B Addition - Addition to sums of 10.
10 B Money - Beginning money equivalents (5¢ = 1 nickel).
11 B Time - Clock reading to the hour.
12 B Systems of Measurement - Beginning equivalent length (3 ft. = 1 yd.).
13 B Geometry - Draws simple geometric figures.
14 C Numeration - Counting to 150.
15 C Place Value - Place value charting to hundreds.
16 C Addition - Two digit sums without carrying but with expanded notation.
17 C Subtraction - Two digit differences without carrying but with expanded notation.
18 C Combination of Processes - Word problems with skills learned to this point plus selection of proper operation to solve problems.
19 C Fractions - With fractions to 1/4 divides single objects and groups of objects.
20 C Money - Practical use of penny, nickel, dime, and quarter.
21 C Time - Solves problems requiring addition or subtraction of hours.
22 C Systems of Measurement - Converts units: inches - feet, pint - quart - cup, dozen - 1/2 dozen.
23 C Geometry - Recognizes and names solid geometric figures.
24 C Special Topics - Reads Roman numerals, to 10; reads thermometer; reads charts and graphs.
25 D Numeration - Counting to 1,000 (reading and writing numerals with skip counting).
26 D Place Value - Makes and reads place value charts to thousands.
27 D Addition - Begins addition with carrying.
28 D Subtraction - Begins subtraction with borrowing.
29 D Multiplication - Does multiplication as repeated addition. Memorizes tables through 5 x 5.
30 D Division - Does division as partition, inverse to addition, and memorizes tables through 25 divided by 5.
31 D Combination of Processes - Solves problems requiring selection and discrimination of many processes.
32 D Fractions - Applies fractional concepts (2/3, 3/4) to objects and groups. Begins formal operations (1/2 x 8 = ?).
33 D Money - Operates with money values to $5.00.
34 D Time - Tells time to the minute and uses time in problems.
35 D Systems of Measurement - Extends linear and volume systems and begins metric system with centimeters.
36 D Geometry - Identifies open versus closed curves, line segments versus lines.
37 D Special Topics - Reads Roman numerals to 30.
38 E Numeration - Identifies odd versus even numbers; rounds and estimates numbers.
39 E Place Value - Uses place value to millions; begins exponents of base 10.
40 E Addition - Performs addition with carrying to thousands.
41 E Subtraction - Does subtraction with borrowing to hundreds.
42 E Multiplication - Does multiplication as repeated addition. Uses associative and distributive principle and does simple multiplication with carrying.
43 E Division - Uses ladder algorithm for division.
44 E Combination of Processes - Solves using n as variable. Does operations with competing processes.
45 E Fractions - Identifies equivalent fractions; adds fraction with a common denominator.

Table 1 (continued)

46 E Money - Adds and subtracts money values using decimal notation.
47 E Time - Uses seconds in time problems.
48 E Systems of Measurement - Adds and subtracts measures by regrouping when necessary.
49 E Geometry - Identifies simple line figures (equilateral triangle, quadrilateral, parallel lines, midpoint, end points, right angle, intersecting lines, perpendicular lines).
50 E Special Topics - Uses simple maps.
51 F Numeration - Uses large numbers, identifies prime numbers, performs operations in base five.
52 F Place Value - Manipulates exponents to ten cubed.
53 F Addition - Adds negative numbers, large sums.
54 F Subtraction - Subtracts negative numbers.
55 F Multiplication - Uses multiplication algorithm with 3 digit numbers.
56 F Division - Uses division algorithm with no remainders; does simple division with remainders.
57 F Combination of Processes - Computes averages; performs multiple operations with common pairs of numbers, (add, subtract, multiply, divide using 90, 31).
58 F Fractions - Adds, subtracts fractions with unlike denominators.
59 F Money - Multiplies and divides money values.
60 F Time - Adds in time problems extending over 12:00. Interprets decade, century, score, fortnight.
61 F Geometry - Assorted topics (area, perimeter, bisection, ray, parts of circle, volume, meters, vertex).
62 F Special Topics - Ratio, percent, function rule.
63 G Numeration - Uses prime numbers to factor composite numbers. Performs operations in bases 3, 7, and 5.
64 G Place Value - Charts large numbers by place value.
65 G Addition - Adds decimal numbers to thousandths, positive and negative numbers; adds with positive numbers of ten.
66 G Subtraction - Subtracts negative and positive numbers, subtracts with positive powers of ten.
67 G Multiplication - Multiplies using positive powers of ten.
68 G Division - Divides with remainders as fractions, using positive powers of ten, decimal numbers, negative numbers.
69 G Combination of Processes - Solves word problems with skills learned.
70 G Fractions - Adds fractions with common denominator algorithm, multiplies fractions.
71 G Time - Uses schedules and 24 hour clock.
72 G Geometry - Calculates circumference, perimeters, areas.
73 G Special Topics - Draws graphs of ordered pairs, uses Venn diagrams for intersection and union.
74 H Numeration - Performs operations in base 2 and base 12.
75 H Place Value - Makes place value charts in other number bases.
76 H Addition - Adds with negative powers of ten.
77 H Subtraction - Subtracts using negative powers of ten.
78 H Multiplication - Multiplies with decimals, with negative numbers, with negative powers of ten.
79 H Division - Divides decimal numbers, positive and negative numbers, using negative powers of ten. Calculates square roots.
80 H Combination of Processes - Solves word problems with skills learned.
81 H Fractions - Multiplies and divides fractions; interprets fractional powers of whole numbers.
82 H Time - Identifies time zones and converts with daylight saving time.
83 H Systems of Measurement - Converts with linear metric measurements.
84 H Geometry - Interprets congruent angles, calculates volumes.
85 H Special Topics - Identifies irrational numbers; follows logic sequence in equations.

ade 1



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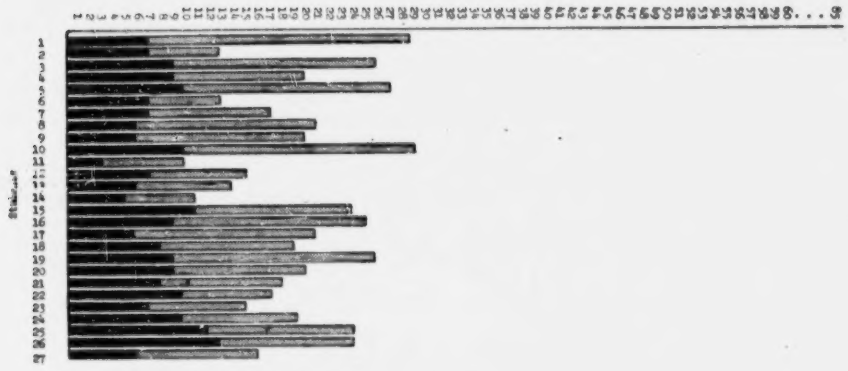

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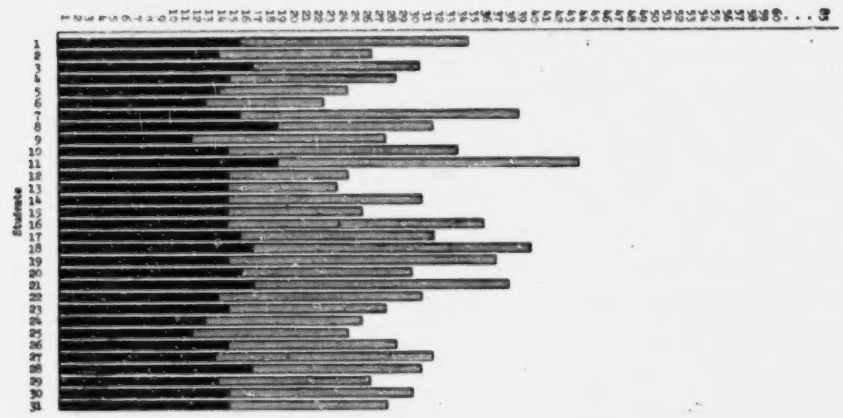

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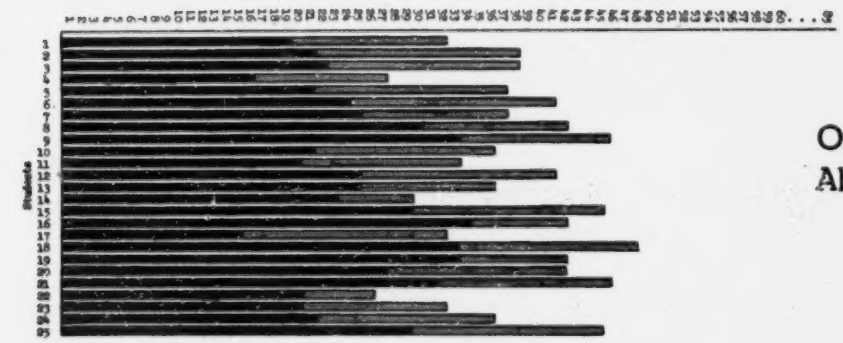

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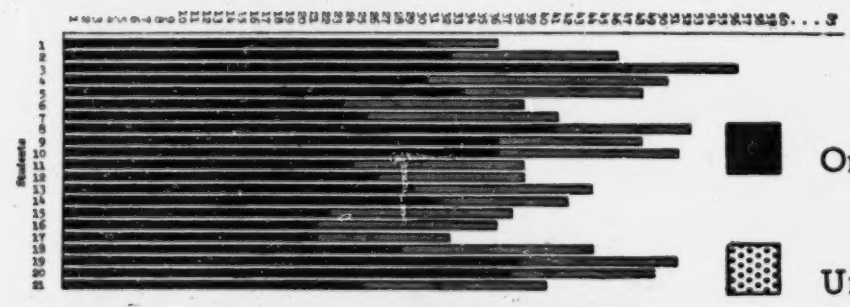

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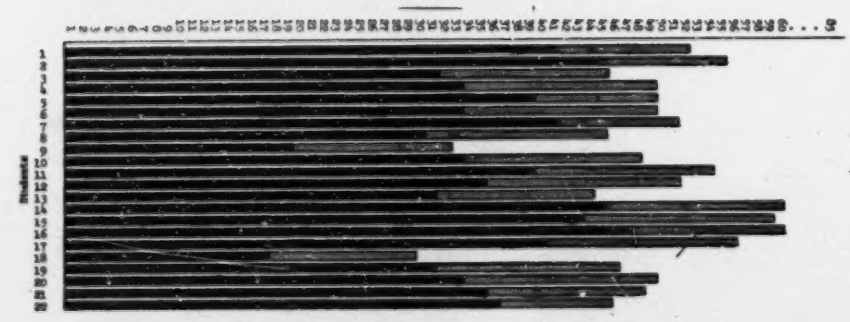


Fig. 1. Placement and Units Mastered in Mathematics During the First Year of the Individualized Instruction Program.

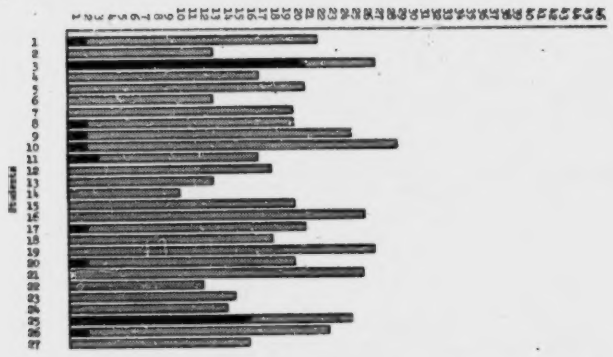
Ordinate is the number of students.
Abcissa is the number of course units.

Original Placement

Units Mastered in One Year of School

ade 1

ade 2



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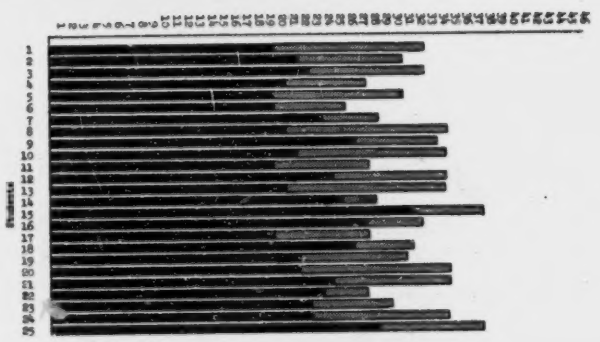

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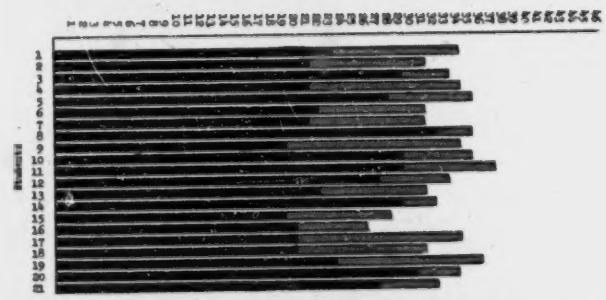

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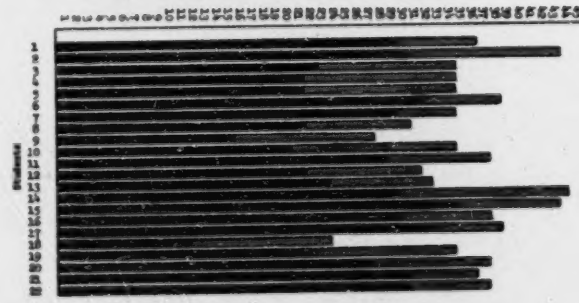

Fig. 2. Placement and Units Mastered in Reading During the First Year of the Individualized Instruction Program.

Ordinate is the number of students.
Abcissa is the number of course units.

Original Placement

Units Mastered in One Year of School

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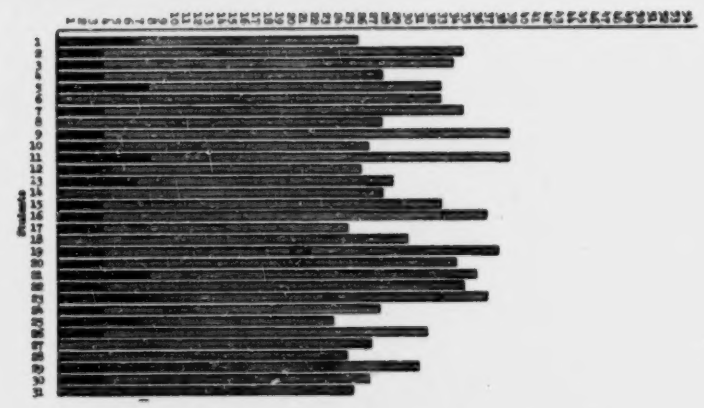

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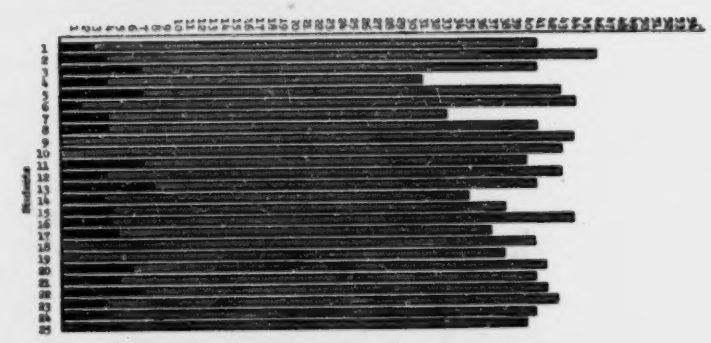

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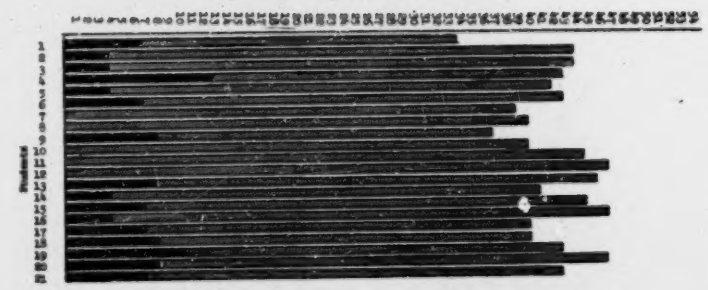

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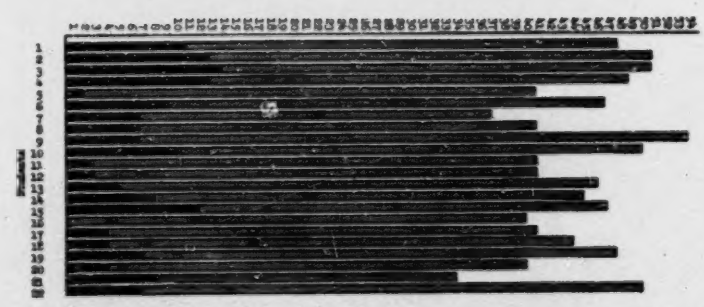

Fig. 3. Placement and Units Mastered in Science During Four Months of the Individualized Instruction Program.

Ordinate is the number of students.
Abcissa is the number of course units.

Original Placement

Units Mastered in Four Months of School